

Solar Energy Manager F

UART Debug Log & Communication Protocol

Combined User Reference

Purpose: This document combines (1) the ASCII debug information actively output by the STM32 and (2) the binary UART protocol used by a host tool to read/write parameters, read snapshots, and perform production/debug operations.

Important: The ASCII debug log and binary protocol frames share USART1, but they use different formats. ASCII logs are for human-readable monitoring; host commands must be sent as binary hexadecimal frames.

1. UART Interface Overview

Item	Specification
Interface	USART1
Baud rate	115200
Data format	8 data bits, no parity, 1 stop bit, no flow control (8N1)
Pins	PA9 = MCU TX, PA10 = MCU RX, full duplex
ASCII output	STM32 actively prints periodic/event logs in text form
Host command format	Binary hexadecimal frame, not ASCII text
Shared-port note	ASCII logs and protocol frames use the same USART1

2. STM32 Active ASCII Debug Output

The MCU prints one status line approximately every 3 seconds for on-site monitoring. This output is not a host command frame and should be viewed in text mode.

```
u:0/0/0 l:0 P:0 s:17725 m:3 ch:0 dn:1 sv:1 b:1 v:4189 i:2051/2051 C:7600 R:98 L:0 F:0 src:5
EE:1/0 ERR:0 ... KEY:0 KH:0 KW:0 KR:0
```

2.1 Periodic Log Fields

Field	Meaning
u:a/b/c	USB triplet: usb_chrg / usb_rechrg / usb_chrg_full. Any non-zero value means active; values may be register masks such as 8.
l	lock_mode. 0 = IP5356 active (INT high); 1 = locked/standby.
P	Low-voltage output-off lock. 1 = output has been disabled due to low battery voltage.
s	Solar input voltage Vin, in mV.
m	MPPT voltage profile/index.
ch	Solar CHRG pin level.
dn	Solar DONE pin level.
sv	SOLAR_VDD_DET. 1 = solar input detected.
b	Displayed battery SOC, in %.
v	Battery voltage VBAT, in mV.
i:x/y	Current in mA: instantaneous / average. Charging is positive; discharging is negative.
C	Nominal/locked capacity, in mAh.
R	Remaining capacity, in mAh.
L	Capacity learning/lock flag. 1 = capacity locked; automatic C update disabled.
F	Full-charge anchor. 1 = full charge has been confirmed.
src	SOC source: 0 = invalid; 2 = fuel gauge; 4 = voltage estimate; 5 = setting/initialization estimate.
EE:a/b	EEPROM: load valid / last save successful.
ERR	Latest EEPROM error code; 0 = no error.
RD:ok/fail	EEPROM read success / failure count.
WR:ok/fail	EEPROM write success / failure count.
CRC	EEPROM CRC failure count.
SLOT	Current normal cyclic-record slot.

SEQ	Current record sequence number.
MC	Most recent learned empty-event capacity, in mAh.
BC	Previous capacity before learning started, in mAh.
EC	Empty-learning event count.
EM:a/b	Emergency record: load valid / last save successful.
ES	Emergency slot number.
ESEQ	Emergency record sequence number.
PL	Whether pre-low-voltage (~3.20 V) emergency save has completed.
CL	Whether critical-low-voltage (~3.10 V) emergency save has completed.
FM	Charging mode used for full-charge determination.
FC	Whether current conditions satisfy the full-charge candidate criteria.
FS	Source mode of the full-charge condition.
FT	Seconds for which full-charge conditions have been continuously confirmed.
KEY	Current debounced key state.
KH	Key hold time in seconds.
KW	Whether the 8-second warning LED flash is active.
KR	Long-press EEPROM clear result: 0 = none, 1 = success, 2 = conditions not met, 3 = write failed.

2.2 Event Logs

Text	Meaning
BOOT	Early boot heartbeat.
SYSTEM RUN ...	Initialization complete. SB indicates whether the system woke from Standby; INT/SV indicate INT and solar-detect status.
KEY SHORT SLEEP	Short press enters software sleep; LEDs off while MCU keeps running.
KEY SHORT WAKE	Short press exits software sleep.
KTEST IGNORE PREACTIVE	Sleep request ignored because solar input or charge/discharge activity is present.
EEPROM CLEAR OK/BLOCKED/FAIL	Result of holding the key for 10 seconds to clear EEPROM.
LOW LEARN END ...	Low-voltage capacity-learning completion event.
IP SLEEP TEST ...	Result of the IP5356 sleep-test command.

3. Binary Host-to-STM32 Communication Protocol

Use binary transmission (hex send mode). Do not type commands as ASCII text.

3.1 Frame Structure

Offset	Length (bytes)	Field	Description
0	2	SOF	Frame header, fixed AA 55
2	1	VER	Protocol version, fixed 01
3	1	CMD	Command code
4	1	SEQ	Sequence number assigned by host; echoed unchanged in response
5	2	LEN	DATA length in bytes, little-endian; maximum 64
7	N	DATA	Payload; length = LEN
7+N	2	PARITY	XOR parity/check field
9+N	2	EOF	Frame tail, fixed 55 AA

Total frame length = 11 + LEN bytes. All multi-byte numeric values are little-endian unless otherwise specified.

3.2 Command Codes

Host CMD	Name	Response CMD	Purpose
01	READ_PARAM	81	Read selected parameter(s)
02	WRITE_PARAM	82	Write parameter(s); currently only capacity C is writable
03	READ_SNAPSHOT	83	Read common parameter snapshot
10	IP_SLEEP_TEST	90	Production/debug test for IP5356 sleep behavior
Other	Unknown command	FF	Error response

3.3 XOR Parity Check

Step	Description
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1. Range	XOR all bytes from VER through the last DATA byte: VER + CMD + SEQ + LEN(2) + DATA(N). SOF, PARITY, and EOF are excluded.
2. Algorithm	Apply bitwise XOR to each byte in sequence to obtain one-byte result P.
3. Storage	PARITY has 2 bytes: low byte = P; high byte = 0x00.
4. Failure handling	If PARITY is incorrect or EOF is not 55 AA, discard the entire frame. Do not execute and do not respond.

Example for C = 7600 mAh:

XOR bytes: 01 02 01 07 00 01 01 00 02 02 B0 1D -> P = A8 -> PARITY = A8 00

3.4 TLV Encoding

Each parameter is encoded as: PARAM_ID(2, little-endian) + TYPE(1) + LENGTH(1) + VALUE(LENGTH).

TYPE	Data type	Description
01	U8	Unsigned 8-bit
02	U16	Unsigned 16-bit, little-endian
04	S16	Signed 16-bit, little-endian, two's complement

4. Parameter Table

ID (hex)	Name	Type	Length	Access	Description
0001	C Capacity	U16	2	R/W	mAh; writable range 500-50000
0002	R Remaining Capacity	U16	2	Read only	mAh
0003	SOC	U8	1	Read only	Displayed battery percentage 0-100
0004	VBAT	U16	2	Read only	Battery voltage, mV
0005	Instantaneous Current	S16	2	Read only	mA; charging positive, discharging negative
0006	Average Current	S16	2	Read only	mA
0007	L	U8	1	Read only	Capacity learning/lock: 0 = unlocked, 1 = locked
0008	F	U8	1	Read only	Full-charge anchor: 0 = not seen, 1 = seen
0009	FM Charging Mode	U8	1	Read only	Charging topology/mode used for full-charge determination
000A	FC Full Candidate	U8	1	Read only	Whether full-charge candidate conditions are currently met
000D	MC Last Measured Capacity	U16	2	Read only	Latest capacity learned at empty event, mAh
000E	EC Empty Event Count	U8	1	Read only	Cumulative empty-learning event count

Note: WRITE_PARAM currently supports only parameter 0001 (C). Writing other IDs returns STATUS=08.

5. Command DATA Formats

5.1 READ_PARAM (CMD=01)

Item	Format / Description
Request DATA	Parameter count N(1) + PARAM_ID0(2) + PARAM_ID1(2) + ... + PARAM_ID(N-1)(2)
Length requirement	LEN = 1 + 2 x N
Response CMD	81
Response DATA	STATUS(1) + TLV count(1) + TLV...

5.2 WRITE_PARAM (CMD=02)

Item	Format / Description
Request DATA	TLV count M(1) + TLV0 + TLV1 + ...
Capacity-only production write	M=01
Capacity TLV	ID=0001, TYPE=02, LENGTH=02, VALUE=capacity in mAh, little-endian
Response CMD	82
Successful response	STATUS=00, TLV count=05, including C, R, SOC, L, F

5.3 READ_SNAPSHOT (CMD=03)

Item	Format / Description
Request DATA	Empty (LEN=0)
Response	Returns C, R, SOC, VBAT, instantaneous current, average current, L, F, FM, FC, MC, EC in one response

5.4 IP_SLEEP_TEST (CMD=10)

Item	Format / Description
Request DATA	Must be empty (LEN=0)
Purpose	Verify that IP5356 FORCE_STANDBY causes the INT pin to go low and that the system automatically recovers.
Production note	Not required for normal production capacity programming.

6. Response STATUS Codes

STATUS	Meaning
00	Success
03	Length error: LEN/DATA does not match command format
04	Range error, e.g. C outside 500-50000 mAh
06	Current state does not permit execution, or EEPROM write failed
08	Unknown parameter ID or type/length mismatch
01	Unknown command; used in CMD=FF error response

7. Capacity C Setting Rules

No.	Rule	Details
1	Allowed ways to change C	a) WRITE_PARAM over UART; b) hold the key for 10 seconds to clear EEPROM, then perform one full-to-empty capacity-learning cycle. Normal charge/discharge operation must not automatically overwrite a locked C.
2	Prerequisites for UART C write	All must be satisfied; otherwise STATUS=06: no effective solar charging; no USB charging/full flag; no output load; valid battery voltage/current samples; $ I \leq 100$ mA; board should preferably be awake, not in user software sleep.
3	Effect after successful write	Update nominal C; estimate SOC from current battery voltage and calculate R; set L=1 and F=1; lock C and disable later automatic learning; save to EEPROM; update battery LEDs according to the new SOC.
4	Priority	UART capacity setting has priority over automatic learning. Once C is locked by UART, it changes only by another UART write or by holding the key for 10 seconds to clear EEPROM and reopen learning.

8. Complete Example Frames

8.1 Set C = 7600 mAh (0x1DB0)

AA 55 01 02 01 07 00 01 01 00 02 02 B0 1D A8 00 55 AA

Field	Value / Meaning
SOF	AA 55
VER	01
CMD	02 = WRITE_PARAM
SEQ	01
LEN	07 00 = 7
TLV count	01
PARAM_ID	01 00 = 0001 (C)
TYPE	02 = U16
LENGTH	02

VALUE	B0 1D = 7600
PARITY	A8 00
EOF	55 AA

8.2 Set C = 5000 mAh (0x1388)

AA 55 01 02 01 07 00 01 01 00 02 02 88 13 9E 00 55 AA

8.3 Set C = 10000 mAh (0x2710)

AA 55 01 02 01 07 00 01 01 00 02 02 10 27 32 00 55 AA

XOR bytes: 01 02 01 07 00 01 01 00 02 02 10 27 -> XOR result = 32.

8.4 Read R, VBAT, and Instantaneous Current

AA 55 01 01 22 07 00 03 02 00 04 00 05 00 25 00 55 AA

Item	Value / Meaning
CMD	01
SEQ	22
LEN	7
DATA	03 02 00 04 00 05 00
Meaning	Read 3 parameters: R, VBAT, instantaneous current

8.5 Read Snapshot

AA 55 01 03 01 00 00 03 00 55 AA

For SEQ=01, the XOR is $01 \wedge 03 \wedge 01 \wedge 00 \wedge 00 = 03$.

9. Building a Frame for Any Capacity

Step	Action	Description
1	Convert capacity	Convert the target mAh value to a 16-bit little-endian value. Example: 7600 -> B0 1D; 5000 -> 88 13.
2	Build fixed body	Using SEQ=01 as an example: 01 02 01 07 00 01 01 00 02 02 <capacity_low> <capacity_high>
3	Calculate parity	XOR every byte in Step 2 to obtain P.
4	Transmit full frame	AA 55 + Step 2 + P + 00 + 55 AA

10. Recommended Production-Test Procedure

Step	Operation	Expected / Notes
1	Connect UART	115200 8N1. MCU TX -> tool RX, MCU RX -> tool TX, common ground.
2	Prepare board	Board awake; no solar input; no USB charging/discharging; current close to 0.
3	Write capacity	Send WRITE_PARAM for C.
4	Check response	Expect CMD=82, STATUS=00, and returned C/R/SOC with L=1, F=1.
5	Verify	Use READ_SNAPSHOT or periodic ASCII logs to verify C, L, and F.
6	If STATUS=06	Check for active charge/discharge or $ I > 100$ mA, remove the condition, and retry.

11. Relationship Between UART Capacity Setting and Capacity Learning

Path / Item	Behavior
Path A - UART writes C	C is locked immediately; R/SOC are estimated from current battery voltage; automatic learning is disabled.
Path B - Hold key for 10 s	Clear EEPROM; C=default 7600; L=0, F=0. After full charge F becomes 1; when discharging to about 3.05 V, C is updated based on net discharged capacity. Learning can continue during the current power-on session; after reboot, if L=1, the final C remains

	locked.
Relationship	The two paths are mutually switchable: UART can set and lock C at any time; a 10-second long press can clear EEPROM and reopen learning.

12. STATE Indicator LEDs (Red / Green)

State	Red LED	Green LED	Meaning
Charging only	Blinking	Off	Solar or USB charging; full charge not yet confirmed
Charging, full, no load	Off	Steady on	Full charge confirmed
Discharging only	Steady on	Off	Output load present
Charging while discharging	Off	Blinking	Charging input and output load are both present
Idle	Off	Off	No charging and no discharging

13. Button-Based Capacity Learning Summary

C can be changed by only two paths: UART capacity write, or a 10-second long press that clears EEPROM and starts a new full-to-empty learning process. Around the 8th second, all four battery LEDs flash as a warning; at 10 seconds the EEPROM clear is executed. After clearing, C=7600, L=0, F=0. Recommended conditions include battery voltage not below about 3.2 V, current roughly within +/-500 mA, no low-voltage lock, no solar input, no USB charging, and no output load.

14. Important Notes

No.	Item	Description
1	Send format	Commands must be transmitted as binary frames. In a serial terminal, select hexadecimal send mode.
2	SEQ	Assigned by the host and echoed unchanged by the STM32; use it to match requests and responses.
3	DATA length	Maximum DATA length is 64 bytes. Frames exceeding this are invalid.
4	Shared USART	ASCII debug logs and binary protocol frames share USART1. Avoid sending commands during long log bursts, or implement frame synchronization in the host tool by searching for AA 55 as SOF and 55 AA as EOF.
5	Implementation basis	This document follows the current firmware behavior. Physical UART is PA9/PA10 full duplex; parity/check method is XOR as described above.

Appendix A. Production Quick Reference

Item	Value
UART	115200 8N1
SOF	AA 55
EOF	55 AA
Protocol version	01
Maximum DATA	64 bytes
Write capacity	CMD=02 / response CMD=82
Read snapshot	CMD=03 / response CMD=83
Writable capacity range	500-50000 mAh
Static current condition before capacity write	I <= 100 mA
Capacity parameter ID	0001